JRC SCIENCE FOR POLICY REPORT

International networking in the building sector

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International cooperation for innovation in the building sector
Aiming to advance innovation in the building sector, the JRC is networking with the best research infrastructures in Europe and the world. Activities focus on resilience, risk assessment, energy efficiency, standards and data repositories. Innovation will support the competitiveness of the European construction industry in Europe and beyond.

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Authors

Georgios Tsionis, Artur Pinto, Alessio Caverzan, George Solomos, Pierre Pegon, Marco Lamperti, Paolo Negro

Executive summary

Policy context

The preparation and implementation of the European Strategy Forum on Research Infrastructures (ESFRI) together with the provision of transnational access to research infrastructures so that scientists can use them to conduct top-level research, are aligned with the 2014-2020 European framework for research and innovation and the Innovative Union Flagship Initiative. Transfer of knowledge and innovation to the European industry in the construction sector will support its competitiveness in the European and global marketplace. Besides, there are significant opportunities for industry in smart, sustainable and inclusive economy and the construction sector in particular can make a substantial contribution to responding to climate change and other environmental and societal changes. Furthermore, innovation and a strong knowledge base are important for the single market, which is the foundation for Europe's industrial strength and productive capacity and create jobs.

Key conclusions

Networking activities among the major research infrastructures with expertise in the building sector are noteworthy in Europe and worldwide. The JRC actively pursues such collaboration and attracts the interest of the best partners, owing to its world-level ELSA experimental facility, scientific capability and sustained commitment to joint research activities.

Research infrastructures are attentive to current and emerging concerns related to the built environment, such as resilience of civil engineering structures and critical infrastructures, energy efficiency in buildings, sustainability in buildings and construction works, adaptation to climate change, multi-hazard approach in risk assessment, complex networks and critical infrastructures, urbanisation, etc.

Furthermore, research infrastructures are devoted to advancing the state-of-the-art and supporting innovation in the fields of innovative experimental technologies, e.g. hybrid cyber-physical testing, numerical simulation methods, and risk assessment and mitigation. Innovation exploits also the opportunities offered by new ICT technologies, for instance for the development of user-friendly interoperable data repositories and Building Information Modelling.

Significant networking activities aim to provide scientific support to decision-makers, including the development of guidelines and standards.

The 1st International Workshop on Resilience demonstrated the worldwide interest on tackling the challenging issues of societal resilience and the need for the earthquake engineering community to strengthen the joint efforts with experts from other relevant fields. There is potential for exchange of experience and knowledge on tools and methodologies, and for their implementation in guidelines.

The European earthquake engineering research community continues the long-standing collaboration in providing transnational access to its research infrastructures, performing joint research and seeking the involvement of new European and international partners, also from sibling disciplines.

Main findings

Despite the substantial progress made in science and technology towards improved performance of the built environment, natural and man-made disasters have persistently been responsible for loss of life, disruption of commerce and financial networks, damaged property, and loss of business continuity and essential services during the last decades. Recent devastating earthquakes remind us of the threat to lives, property, infrastructures and the overall social and economic wellbeing of individuals, communities and countries.

Therefore, resilience of infrastructures is of fundamental importance for recovering from a disaster. Major research activities on resilience-based earthquake engineering have been supported and coordinated by large research groups and networks. Today, the principal challenge is how to use in practice resilience-based seismic engineering to steward our built environment and make it safer, resilient and sustainable in the future.

The scientific topics that are of common interest to the major research infrastructures include:

- technical, economic and social aspects of seismic resilience of civil engineering structures, complex networks and critical infrastructures against multiple hazards,
- advanced experimental methods and technologies (hybrid cyber-physical testing) in earthquake engineering,
- interoperable repositories for sharing and exchanging data,
- seismic vulnerability assessment and mitigation measures,
- guidelines and standards for the design and retrofit of structures in seismic areas,
- energy efficiency in buildings,
- adaptation to climate change,
- sustainability in buildings and construction works.

Related and future JRC work

Future work of the JRC regarding networking and advancement of earthquake engineering research infrastructures will focus on performing joint research and dissemination activities with the existing partners and extending the collaboration to other European and international research infrastructures.

Quick guide

The present report covers the activities that were performed in 2016 and examines the outlook for future joint activities in the context of the collaboration of the Safety and Security of Buildings Unit of the JRC with the best relevant research infrastructures in the European Union and with international partners in the USA, Japan, South Korea and China. In more detail, the report focuses on i) the establishment and first implementing steps of collaboration agreements with the Cyprus University of Technology, Purdue University and Korea Construction Engineering Development Collaboratory Management Institute; ii) the joint activities with the Building Research Institute of Japan; iii) the international events organised by the Safety and Security of Buildings Unit; iv) the proposed future collaboration agreements and v) a proposal for a Horizon 2020 project by the major European research infrastructures for seismic engineering and seismology.

1 Introduction

The RINET institutional project of the Joint Research Centre (JRC) focuses on networking of research infrastructures and advancing innovative aspects of safety and sustainability in the construction sector. The project pursues four objectives:

— build up a sustained platform for collaboration of research infrastructures in earthquake engineering in the European Union, encompassing the objectives of the European Strategy Forum on Research Infrastructures (ESFRI), and focusing on safety and sustainability in the building sector,

— establish a framework for collaboration with leading networks and research infrastructures outside the European Union,

— develop new technologies and standards for the efficient and joint use of research infrastructures,

— evaluate innovative technologies, such as robotics and hybrid cyber-physical testing.

The preparation and implementation of the ESFRI together with the provision of transnational access to research infrastructures so that European scientists can use them to conduct top-level research, in collaboration with industry, are aligned with the 2014-2020 European framework for research and innovation ([1]) as well as the Innovative Union Flagship Initiative ([2]). Transfer of knowledge and innovation to the European industry in the construction sector will support its competitiveness in the European and global marketplace ([3]). Besides, there are significant opportunities for industry in smart, sustainable and inclusive economy and the construction sector in particular can make a substantial contribution to responding to climate change and other environmental and societal changes ([4]). Furthermore, innovation and a strong knowledge base are important for the single market, which is the foundation for Europe's industrial strength and productive capacity and create jobs ([5]).

The present report covers the activities that were performed in 2016 in the context of the collaboration of the Safety and Security of Buildings Unit of the JRC with relevant research infrastructures in the European Union and with international partners in the USA, Japan and South Korea. In particular, the report focuses on i) the establishment and first implementing steps of collaboration agreements with the Cyprus University of Technology, Purdue University and Korea Construction Engineering Development Collaboratory Management Institute; ii) the joint activities with the Building Research Institute of Japan; iii) the international events organised by the Safety and Security of Buildings Unit; iv) the proposed future collaboration agreements and v) a proposal for a Horizon 2020 project with the major European research infrastructures for seismic engineering and seismology.

([1]) Regulation (EU) No 1291/2013 of the European Parliament and of the Council of 11 December 2013 establishing Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020)

([2]) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Europe 2020 Flagship Initiative Innovation Union. COM(2010) 546 final

([3]) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. For a European Industrial Renaissance. COM(2014) 14 final

([4]) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. An integrated industrial policy for the globalisation era putting competitiveness and sustainability at centre stage. COM(2010) 614 final

([5]) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Commission Work Programme 2015, A New Start. Annex 1. COM(2014) 910 final

2 Progress on new and existing collaboration agreements

2.1 Cyprus University of Technology

2.1.1 Background

A Memorandum of Understanding was signed in 2016 between the JRC and the Cyprus University of Technology with the aim to establish the basis for future collaboration between the parties in the fields of resilience to earthquakes, structural and seismic testing and energy efficiency of buildings. The following scientific subjects of common interest were proposed:

- advanced experimental methods in earthquake engineering,
- seismic resilience of civil engineering structures and critical infrastructures,
- seismic vulnerability assessment and retrofit of existing structures,
- numerical simulation,
- energy efficiency in buildings.

Collaboration on the scientific subjects may take the form of exchange of knowledge, information and data; joint research activities; pre-normative and co-normative research related to the European standards for structural design (the EN Eurocodes); exchange of personnel; joint training and dissemination activities.

2.1.2 Activities

A meeting between the JRC and the Cyprus University of Technology was organised on the 24th of June 2016 at the JRC/Ispra. The objective of the meeting was to exchange information on the current and planned activities of the two sides and to discuss the future actions in the framework of the Memorandum of Understanding. The meeting started with a presentation by Prof Chrysostomou to all staff of the Safety and Security of Buildings Unit (E.4) of the JRC, followed by a session of presentations by E.4:

- Cyprus University of Technology: earthquake engineering and large structures group research, C. Chrysostomou, Cyprus University of Technology,
- Mixed variable control for enhanced testing quality, J. Molina, JRC,
- State of implementation of the Eurocodes in the European Union, S. Dimova, JRC,
- Eco-energy efficient envelopes for innovative buildings, A. Caverzan, JRC,
- Towards seismic risk assessment of the European urban areas, G. Tsionis, JRC.

The following further steps were delineated:

1. discuss the needs of the Cyprus University of Technology for transfer of knowledge on experimental testing,
2. define common work in subjects of mutual interest, indicatively: study of methods and development of guidelines for seismic retrofit of buildings, seismic risk assessment, integrated retrofit for earthquake resistance and energy efficiency, implementation and further development of the Eurocodes and other standards in construction,
3. consider the preparation of a proposal for the Horizon 2020 call 'WIDESPREAD' by the Cyprus University of Technology, the JRC, the École Centrale de Nantes and Imperial College, where the JRC will mainly contribute know-how on experimental testing,
4. invite students of the Cyprus University of Technology to apply for trainee positions at the JRC,

5. consider the involvement of other JRC Units and Departments of the Cyprus University of Technology.

Subsequently, a meeting took place at the Cyprus University of Technology on the 9th of October 2016, where implementing actions were discussed in detail. The possibility of short visits of engineers/researchers from the Cyprus University of Technology to the JRC was discussed, with the aim of transfer of knowledge on experimental setup design, calibration of instruments and loading devices, safety of technicians and visitors during testing, data collection, analysis and reporting. Recalling the explosion in 2011 that destroyed an electricity power plant that provided more than 50 % of the country's needs, the collaboration on the numerical simulation of critical infrastructures under blast loading was also discussed. It was also agreed to jointly perform a scenario-based risk assessment for Cyprus using building inventories with different levels of detail and possibly different sets of fragility curves.

2.2 Purdue University

2.2.1 Background

A Collaborative Research Agreement was signed in 2016 between the JRC and Purdue University with the general objective to contribute more effectively to understanding and resolving scientific issues in the field of hybrid testing and resilience of buildings and civil infrastructures to natural hazards.

Purdue University has been appointed to lead the Network Coordination Office for the Natural Hazards Engineering Research Infrastructure (NHERI). NHERI is a five-year project financed by the US National Science Foundation with an anticipated funding amount of about €18 million.

The following scientific subjects of common interest are proposed for collaboration:

— scientific, economic and social issues relating to seismic risk resilience, vulnerability and mitigation of seismic risk for civil engineering structures and critical infrastructures,

— standards for the design and retrofit of structures in seismic areas,

— experimental technologies, research data repositories and numerical simulations related to structural engineering,

— sustainability in buildings and construction works.

Collaboration on the scientific subjects may take the form of exchange of knowledge, information and experimental data; joint research activities; joint training and dissemination activities, possibly involving other international partners.

2.2.2 Activities

A meeting between the JRC and the Purdue University was organised on the 22nd of June 2016 at the JRC/Ispra. The objective of the meeting was to exchange information on the current and planned activities of the two sides and to discuss the future actions in the framework of the Collaborative Research Agreement. The meeting started with a presentation by Prof Dyke and Prof Ramirez to all staff of the Safety and Security of Buildings Unit (E.4), followed by a session of presentations by E.4:

— JRC-Purdue Collaborative Research Agreement: Opportunities and research coordination, Shirley Dyke & Julio Ramirez, Purdue University,

— Mixed variable control for enhanced testing quality, Javier Molina, JRC,

— The new ELSA database of experimental results, Pierre Pegon, JRC,

— State of implementation of the Eurocodes in the European Union, Silvia Dimova, JRC,

— Eco-energy efficient envelopes for innovative buildings. Alessio Caverzan, JRC,

— Towards seismic risk assessment of the European urban areas. Georgios Tsionis, JRC.

The following further steps were delineated:

1. exchange information on the current and future work of the two sides,
2. discuss operating procedures, membership and concrete actions towards more efficient co-ordination of existing activities, including the following topics for collaboration:
   (a) control schemes for hybrid simulation in experimental testing,
   (b) reliability assessment techniques for the results of hybrid tests,
   (c) online repository of experimental data
   (d) storing and sharing of images of post-earthquake damage (considering the involvement of other JRC Units that work on remote sensing),
   (e) international collaboration of earthquake engineering research infrastructures,
   (f) resilience and sustainability of buildings and infrastructures,
3. organise a special session on hybrid testing in the 16th World Conference on Earthquake Engineering (see 2.2.3) and investigate possibilities for establishing an international research network in hybrid simulation.

2.2.3 Special session on hybrid testing at the 16th World Conference on Earthquake Engineering

Hybrid simulation, a powerful cyber-physical technique, has been used in earthquake engineering applications for several years and has been extended to real-time and geographically-distributed experiments. In the framework of the Collaborative Research Agreement with Purdue University and as a follow-up of the EU-US-Asia workshop on hybrid testing that took place in Ispra on 5 and 6 October 2015 ([6]), a special session entitled 'Hybrid cyber-physical simulation: state-of-the-art and future prospects in USA and Europe' was proposed for the 16th World Conference on Earthquake Engineering.

The objective of the special session is to bring together researchers from Europe and the USA to discuss recent developments, challenges and future prospects. Contributions to the special session are expected to increase the broader knowledge in the field, with focus on: the preparation of the testing setup to meet stability and performance objectives; tolerance to hardware/software malfunctions; reliability of test results related to the effect of numerical and experimental errors; and advances toward model complexity. The acceptance of hybrid simulation by the broader experimental testing community and possible applications beyond earthquake engineering will be debated as well. The special session will be integrated with two other special sessions on the same topic during the 16WCEE.

2.3 KOCED CMI

A Collaborative Research Agreement was signed in 2016 between the Joint Research Centre and the Korea Construction Engineering Development Collaboratory Management Institute (KOCED CMI). This agreement is aimed at building a sustained platform for international collaboration of research infrastructures in earthquake engineering and structural dynamics.

KOCED CMI is a world leading research institution in the fields of transport and construction, with cross-cutting technologies based on cyberinfrastructure testing facilities covering structural safety, mitigation of seismic risk, climate change and

([6]) Enhancing the collaboration of earthquake engineering research infrastructures. JRC Science for policy report, EUR 27648 EN, 2015.

extreme environment actions, energy efficiency and extreme events loads. At international level, KOECD CMI collaborates with the most important networks, namely NEES (USA), E-DEFENSE (Japan) and NCREE (Taiwan).

The general objective of the agreement is to contribute more effectively to understanding and resolving scientific issues in the field of hybrid testing and seismic resilience of civil engineering structures and critical infrastructures, as well as in the fields of sustainability and energy efficiency of building constructions. The following specific objectives will be sought:

1. obtain the scientific data needed to perform seismic resilience, vulnerability assessment and risk mitigation of civil engineering structures and critical infrastructures,
2. improve the co-ordination and effectiveness of co-operation efforts between KOCED CMI and the JRC in the field of resilience and protection of civil engineering structures and critical infrastructures against natural hazards and extreme events,
3. promote mutual interest and co-operation in understanding and resolving issues related to the mitigation of seismic risk, including the preparation of guidelines for the seismic retrofit of buildings,
4. deepen the understanding of the scientific, economic and social issues relating to seismic resilience, vulnerability and mitigation of seismic risk,
5. deepen the understanding and promote the exchange of South Korean and European (Eurocodes) construction standards for the design of structures in seismic areas,
6. exchange and share best practices and experience on experimental technologies and numerical simulations related to structural engineering,
7. explore a coordinated approach for considering issues of adaptation to climate change, sustainability and energy efficiency in buildings and construction works, and ICT applications / Building Information Modelling covering the whole lifecycle.

2.4 Japan Building Research Institute

On April 14th, 2016 at 21:26 JST (12:26 UTC), a shock with a magnitude 6.2 struck the Japanese prefecture of Kumamoto. A second and stronger shock followed the day after with a magnitude 7.0. The two earthquakes in total have injured about 3,000 and killed at least 50 people. Severe damage occurred in Kumamoto and Ōita Prefectures, with structural collapses and landslides. More than 44,000 people were evacuated from their homes due to the disaster.

The European Commission – Joint Research Centre, Safety and Security of Buildings Unit, in close cooperation with the Japanese Building Research Institute (BRI) organised a field survey soon after: May 9th-13th. The survey regarded the most affected zone within the epicentral area. Besides the city of Kumamoto and its outskirts, Uto city, Minamiaso and Mashiki town were visited together with their rural area, which were affected by several landslides. All the results of the survey, with an ample photographic record, are collected in a technical report that is being drafted in collaboration with BRI.

Figure 1. Surface rupture in the epicentral area: Mashiki Town, 9th May 2016

3 1st International workshop on resilience

Recent devastating earthquakes remind us of the threat to lives, property, infrastructures and the overall social and economic wellbeing of individuals, communities and countries. Despite the substantial progress made in science and technology towards improved performance of the built environment, natural disasters, acts of terrorism, and social unrest have persistently been responsible for loss of life, disruption of commerce and financial networks, damaged property, and loss of business continuity and essential services during the last decades. Many physical infrastructures are vulnerable to natural hazards (e.g. along coastlines and in earthquake-prone regions) as well as man-made hazards, and across the world the risk of damage due to hazardous events continues to increase.

Resilience of infrastructures is of fundamental importance for recovering from a disaster. Major research activities on resilience-based earthquake engineering have been supported and coordinated by large research groups and networks. However, even with this progress the earthquake engineering community is still facing many new challenges. Today, a principal question is how to use in practice resilience-based seismic engineering to steward our built environment and make it safer, resilient and sustainable in the future.

To address these fundamental issues, the 1st International Workshop on Resilience has been co-organized by the Politecnico di Torino and the JRC. The workshop took place in Turin on 20-21 September and at the JRC/Ispra on the 22nd of September (Figure 2). Its aims have been to develop a common global vision for earthquake engineering and resilience design, while recognizing unique regional traditions and to assess and develop strategies on how to improve community resilience against a major event. The workshop was sponsored by the American Society of Civil Engineering (ASCE) and the Pacific Earthquake Engineering Research Centre (PEER).

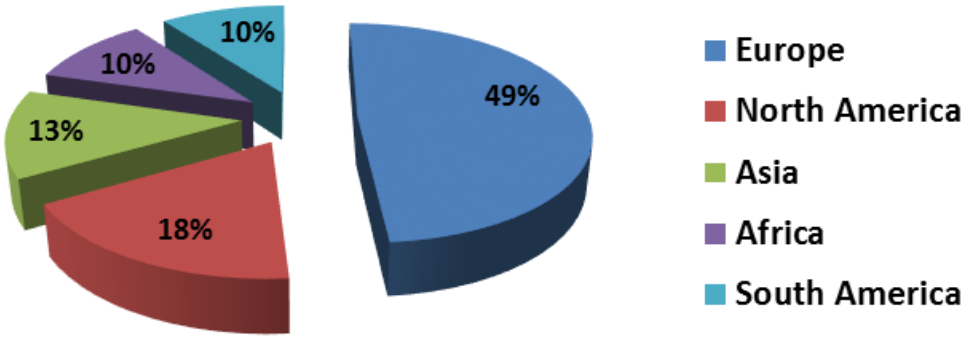
Figure 2. The participants of the 1st International Workshop on Resilience at the JRC Visitors' Centre

The workshop examined the state of the knowledge and views on the new directions for resilience-based design, including technologies and modelling tools for the design and improvement of new and existing structures and infrastructures, cost-effective risk management, impact on society and economy, and their implementation in codes and engineering practice. Moreover, representatives of Horizon 2020 projects on resilience presented their activities.

The international outreach of the workshop is evidenced by the participation of more than 50 researchers – both senior and some of the most promising young ones who will lead

the activities in the decades to come – from Europe, North and South America, Asia and Africa, as shown in Figure 3.

Figure 3. Origin of the workshop participants



During the workshop, a path has been charted for tackling the challenging issues in assessment and repair of existing structures, design of new structures and infrastructure, cost-effective risk management, and impact on society and economy in order to increase the resilience of the communities in which we live. In this direction, it is worth citing the impressive ongoing program set up by the US National Institute of Standards and Technology, in which the Center of Excellence for Risk-Based Community Resilience Planning (NIST-CoRE) has also been created.

The world-leading engineering community that was brought together at the workshop is eager to continue the coordinated effort and meet again at the 2nd Workshop that will be hosted in Nanjing and Shanghai in China on 3-5 November 2017. In the meantime, selected works will be published in a special issue of the ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems: Part A. Civil Engineering, while extended abstracts will be collected in a JRC publication.

4 Future collaboration agreements

4.1 Argonne National Laboratory

Following the 1st International Workshop on Resilience (see section 3), a delegation of the Argonne National Laboratory visited the JRC on the 23rd of September 2016 to present their activities relevant to resilience and to discuss possibilities for future collaboration. The programme of the visit included the following presentations:

— Adaptation of structural design to climate change, S. Dimova, JRC.E.4,

— Towards seismic risk assessment of the European urban areas, G. Tsionis, JRC.E.4,

— Resilience of networked interdependent infrastructures, G. Giannopoulos, JRC.E.2,

— Critical infrastructures resilience, presentation D. R. Verner & F. Petit, Argonne National Laboratory.

It was proposed to extend the existing collaboration agreement between JRC and Argonne National Laboratory ([7]) to the fields of i) physical security and all hazard approach, ii) resilience of complex networks and urban areas and iii) energy and climate security. The scope of the proposed agreement is to contribute more effectively to understanding and resolving scientific issues related to the aforementioned topics and to provide scientific support to decision-makers.

The following objectives are proposed:

1. to integrate each institutions' areas of expertise and facilities and provide mutual support in obtaining impartial, sound and balanced scientific evidence and engineering assessment for decision support,
2. to identify scientific and technical issues and to investigate how the expertise and facilities of the Joint Research Centre and the Argonne National Laboratory can be used for mutually beneficial further research and development,
3. to promote mutual interest and co-operation for improved understanding of the threats, risks, and opportunities related to physical security, resilience and energy and climate security,
4. to validate technical approaches, methods and practices of both sides through inter-institution comparison of methods,
5. to perform work within the existing institutional research programs and in a complementary way to leverage both laboratories' scientific output and increase its impact and dissemination.

The objectives will be reached through complementary and mutually beneficial activities, such as:

1. engage in dialogue and exchange relevant, non-proprietary scientific and technological information,
2. identify research needs and implement research projects of mutual interest,
3. identify best practices and tools, investigate the scope of guidelines/standards, promote their development and coordinate the contribution of relevant experts from Europe and the United States,
4. conduct transatlantic pilot studies to compare and contrast methodologies that currently exist in Europe and the United States,
5. organise joint dissemination activities, possibly with the involvement of other international partners.

([7]) Collaboration Agreement between the Department of Energy of the United States of America and the Joint Research Centre of the European Commission regarding Research and Development in energy-related field

4.2 Utrecht University

A collaboration agreement is proposed to continue and broaden the existing collaboration with Utrecht University in the fields of water resources and floods. The collaboration will extend to the fields of water resources and extremes; water and innovation; toxicology, alternative testing methods, biologicals, biokinetics and human/environmental risk assessment; atmospheric sciences; nuclear; seismic and multi-hazard resilience of urban regions and infrastructures; solar/renewable energy; standardisation and reference methods.

The foreseen activities include joint supervision of PhD students, exchange of research staff, participation in PhD defence committees, limited teaching activities and joint publications.

Within this initiative, the Safety and Security of Buildings Unit of the JRC established a contact with the Department of Earth Sciences in order to investigate the possibilities for collaboration. The contact person at the Faculty of Geosciences is interested in earthquake hazard, including induced earthquakes, is responsible for providing information to the public and media after earthquake events and is coordinating a course on natural hazards that attracts around 100 students per cycle. The topics for collaboration that were proposed by E.4 include: i) risk assessment and mitigation in the built environment against natural (including induced seismicity) and man-made hazards; ii) concurrent retrofit of buildings to meet the requirements for seismic safety and energy efficiency; iii) impact of climate change on design actions for structures; iv) communication to the public integrating information on seismicity and performance of structures and v) applications of virtual cities and infrastructures for resilience assessment. The collaboration should build on the complementarity of hazard and vulnerability issues.

5 Proposal for European research project on integrating and opening research infrastructures

Following the meeting of the representatives of the major European research infrastructures in earthquake engineering that was organised by the JRC in October 2015 ([8]), it was agreed to present a joint proposal to the call on 'Integrating and opening research infrastructures of European interest' of the 2016-2017 work programme of Horizon 2020 on excellent science. The call included a topic on integrating activities for advanced communities and in particular for research infrastructures for earthquake hazard.

The overall objective of the proposed project called 'Seismology and Earthquake Engineering Research Infrastructure Alliance for Europe' (SERA) is to give a significant contribution to improve the access to data, services and research infrastructures, and deliver solutions based on innovative research and development in seismology and earthquake engineering, aiming at reducing the exposure of our society to the risk posed by natural and anthropogenic earthquakes.

The project involves institutions (see Table 1) and competences from seismology, geotechnical engineering, earthquake engineering and anthropogenic hazards, and fosters durable integration of the research field. It comprises Networking, Transnational and Virtual Access, as well and Joint Research Activities. It will contribute to supporting the reduction of vulnerability of European citizens and constructions to earthquakes.

The project will advance the state-of-the-art in open collection and access to seismological data for natural and anthropogenic seismicity, assessment of shaking and damage during a seismic emergency, seismic risk assessment at European scale, harmonisation of earthquake hazard assessment with a view to its implementation in European standards, citizen-based seismology, experimental and observational monitoring technologies, etc.

Furthermore, SERA will exploit synergies with relevant ESFRI infrastructures, in particular the European Plate Observing System (EPOS). EPOS aims at creating a pan-European infrastructure for solid Earth science to support a safe and sustainable society. Through integration of data, models and facilities, EPOS allows the Earth science community to develop new concepts and tools for key answers to scientific and socio-economic questions concerning geo-hazards and geo-resources as well as Earth sciences applications to the environment and to human welfare. SERA will provide a substantial contribution to EPOS by developing the component of earthquake engineering, validating existing and developing new service pillars of virtual access to data and products and by offering transnational access to a coherent set of large research infrastructures.

The JRC will offer transnational access to the ELSA reaction wall facility and will contribute to the networking activities related to the maintenance/expansion of the SERIES database (www.dap.series.upatras.gr) and the roadmap for integration of earthquake engineering and seismological data, as well as to the joint research activities on advanced methods for hybrid simulation and testing. Furthermore, the JRC will participate to the management of the project, the strategy for integration with EPOS, dissemination activities and dialogue with stakeholders.

([8]) G. Tsionis, F. Taucer, A. Pinto; Enhancing the collaboration of earthquake engineering research infrastructures; EUR 27648 EN; doi:10.2788/021850

Table 1. Organisations participating in the SERA proposal

Organisation	**Country**
Eidgenössische Technische Hochschule Zürich	Switzerland
Centro Europeo di Formazione e Ricerca in Ingegneria Sismica	Italy
Joint Research Centre – European Commission (JRC)	Belgium
Commissariat à l'Energie Atomique et aux Energies Alternatives	France
Laboratorio Nacional de Engenharia Civil	Portugal
University of Patras	Greece
University of Bristol	United Kingdom
Institute of Earthquake Engineering and Engineering Seismology SS Cyril and Methodius University Skopje	Former Yugoslav Republic of Macedonia
University of Cambridge	United Kingdom
Università degli Studi di Trento	Italy
Universidade de Porto	Portugal
Universidad Politecnica de Madrid	Spain
Bogazici Universitesi	Turkey
Aristotelio Panepistimio Thessalonikis	Greece
Helmholtz Zentrum Potsdam Deutsches Geoforschungszentrum	Germany

Koninklijk Nederlands Meteorologisch Instituut	Netherlands
Institut National de Cercetare-Dezvoltare Pentru Fizica Pamantului	Romania
National Observatory of Athens	Greece
Uppsala Universitet	Sweden
Agencia Estatal Consejo Superior de Investigaciones Cientificas	Spain
Natural Environment Research Council	United Kingdom
Euro-Mediterranean Seismological Centre	France
Università degli Studi di Napoli Federico II	Italy
Centre National de la Recherche Scientifique	France
Analisi e Monitoraggio del Rischio Ambientale Scarl	Italy
Stiftelsen NORSAR	Norway
Instytut Geofizyki Polskiej Akademii Nauk	Poland
Istituto Nazionale di Geofisica e Vulcanologia	Italy
Instituto Superior Técnico	Portugal
Bureau de Recherches Géologiques et Minières	France
Universitetet i Bergen	Norway

6 Conclusions

The Safety and Security of Buildings Unit is active in networking activities with the best partners in Europe and the world.

Collaboration agreements were recently concluded with the Cyprus University of Technology, Purdue University in the USA and the Korea Construction Engineering Development Collaboratory Management Institute. During 2016, the first implementing steps were taken within these agreements and a joint field survey to the prefecture of Kumamoto that was affected by the earthquakes on April 2016 was organised in the framework of the existing agreement with the Building Research Institute of Japan.

Following the expression of interest by the Argonne National Laboratory in the USA and the University of Utrecht in the Netherlands, discussions were initiated regarding possible future agreements in the areas of physical security and all hazard approach, resilience of complex networks and urban areas, and energy and climate security.

The 1st International Workshop on Resilience was co-organised by the JRC and the Technical University of Turin. It gathered more than 50 senior and young researchers from Europe, North and South America, Asia and Africa to examine the state of the knowledge and debate on the new directions for resilience-based design.

Building on the past activities for enhanced collaboration of European research infrastructures in earthquake engineering, a proposal was submitted to the call on 'Integrating and opening research infrastructures of European interest' of the 2016-2017 work programme of Horizon 2020. The proposed project will create a 'Seismology and Earthquake Engineering Research Infrastructure Alliance for Europe' through three types of activities: transnational access, joint research and networking.

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Annex 1. Scientific programme of the 1st International Workshop on Resilience

Hosting Institutions

POLITECNICO DI TORINO

European Commission

European Research Council
Established by the European Commission

1st International Workshop on Resilience

September 20-22, 2016
TORINO - ISPRA • ITALY

TORINO - ISPRA, Italy 20 -22 September 2016

Conference venues:
Politecnico di Torino (Castello del Valentino), Torino
European Commission's Joint Research Center (JRC), Ispra

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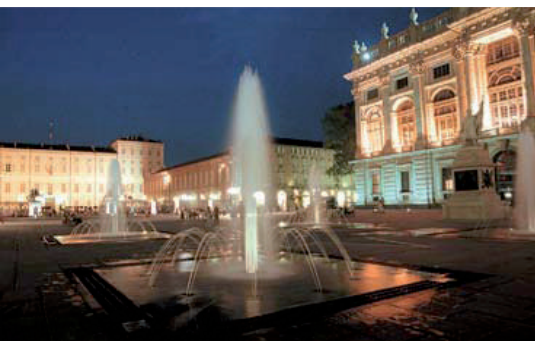

WORKSHOP PRESENTATION

During the last decade several devastating earthquakes have occurred, reminding us that destructive events still threaten the lives of millions, property, social structure, and economic wellbeing of individuals, communities, and countries all over the world.

The recent events in Europe, Asia and America demonstrate that natural and manmade hazards represent one of the most considerable threats to communities in Europe and on a global scale.

In this context, the 1st International Workshop on Resilience will address topics such as recovery, mitigation strategies, innovative technologies, resilience and downtime estimation, economic aspects etc. To address these pressing issues has never been more timely and relevant for resilience and sustainable development.
The workshop will provide an opportunity for researchers working on resilience from various domains to present and discuss their current work and discuss work in progress.

The aim of the workshop is to develop a common global vision for Disaster Resilience, while recognizing unique regional traditions. The goal of the workshop is to present and compare different strategies and frameworks on how to improve community resilience against a major event.

The first two days of the workshop will take place in Torino in one of the most prestigious Politecnico conference facilities, the Hall of Honour of the Valentino Castle a 16th century royal residence, while the third day will be hosted in the European Commission's Joint Research Center (JRC), a science hub located in Ispra on the Lake Maggiore, about 130 km far from Torino.

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WORKSHOP VENUES

September Tuesday 20 and Wednesday 21
Castello del Valentino, Torino

Recognised by UNESCO in 1997 as a part of the Residences of the Royal House of Savoy (Italy) World Heritage site, and situated on the banks of the River Po, the Castello del Valentino is an important historic monument in Piedmont's regional capital, and hosts the main offices for the Department of Architecture at Politecnico di Torino. The workshop will take place in the beautiful Hall of Honour. This large, lofty hall is the most significant area in terms of iconography; architecturally it marks the link between the two symmetrical apartments for the Princess Regent Cristina and the Crown Prince through the loggia and the double ramp staircase. The background of painted scenes on the walls draws attention to the many and long-standing alliances that were forged between the dukes of Savoy and the kings of France. Restoration of the frescoes and vaulted ceiling in the hall began in the early 1990s. A new floor of terracotta tiles was also laid, in keeping with the original materials. The Hall of Honour is now used as meeting room with up-to-date audiovisual equipment.

September Thursday 22:
JRC site, Ispra

The JRC Site in Ispra, the third biggest EU Commission site after Brussels and Luxembourg, covers an area of 167 hectares with ca 138 buildings hosting ca 1850 staff. After more than 50 years of development, Ispra is firmly established as one of Europe's leading research campuses. Nested in the beautiful setting of the Italian lakes, Ispra provides a fascinating, multicultural working environment for people from all over Europe and beyond.

WORKSHOP REGISTRATION FEES

Early registration fee (until June 30, 2016)
EUR 300,00 - VAT 22% included

Late registration fee (after June 30, 2016)
EUR 350,00 - VAT 22% included

Registration fees include:
- access to all scientific sessions on September 20, 21 in Turin and 22 in Ispra;
- coffee breaks and buffet lunches;
- transfer to and from Ispra;
- welcome cocktail reception on September 19;
- social dinner on September 20;
- city tour "Turin under the stars" on September 21.

The registration form is available at
www.workshop-torino2016.resiltronics.org/registration.html

SCIENTIFIC PROGRAMME

Monday, September 19

Attendees arrival in Turin
19:00 Welcome cocktail reception
Hotel NH Santo Stefano via Porta Palatina, 19

Tuesday, September 20

Castello del Valentino - Hall of Honour

8:45 Workshop opening
M. Gilli - Rector of the Politecnico di Torino
C. Scavia - Head of DISEG Department
S. Bovo - Civil Protection Regione Piemonte

OPENING LECTURES

9:00 Resilience: the structural engineering dilemma.
M. Bruneau – A. Reinhorn, USA
9:30 Consideration of time dependent risk in resilience assessment. *A. Kiremidjian – D. Lallemant – L. Ceferino-Rojas, USA*
10:00 Prescription for economic resilience to natural hazards. *H. Tatano, Japan*
10:30 The social landscape of disaster resilience.
S. Cutter, USA

11:00 Break

CODES AND STANDARDS

11:15 Holistic design of concrete structures for resilience to blast, impact, fire and earthquake.
M. N. Fardis, Greece
11:45 Resilient seismic codes in Chile: a possible challenge. *G. R. Saragoni, Chile*
12:00 Building resilient communities: a systemic approach based on lessons and challenges from grass root level initiatives in India and Japan. *B. Misra, India*
12:30 Sustainability and resilience in seismic areas: an exciting challenge for civil engineers.
P. Clemente – G. Bongiovanni – G. Buffarini – F. Saitta, Italy

12:45 Break

EUROPEAN FRAMEWORKS

13:45 Introduction to European Projects.
A. P. Contaretti, European Commission–Belgium
14:00 Operationalize European resilience management guidelines in urban transport system: The RESOLUTE project approach (H2020 project). *E. Bellini – P. Nesi, Italy*
14:15 Application of resilience concepts to critical infrastructure in the IMPROVER project (H2020 project). D. Lange – D. Honfi, Sweden – *L. Petersen, France – B. Rød – C. Pursiainen, Norway*
14:30 The PEOPLES framework for building, community and State level.
G. P. Cimellaro, Italy
14:45 The RESILENS project approach (H2020 Project).
W. Hynes, Ireland
15:00 DARWIN- H2020 project – Expect the unexpected and know how to respond. Current findings and way forward.
L. Save, Italy
15:15 Smart Mature Resilience – SMR (H2020 project). Developing resilience management guidelines for more resilient cities in Europe.
P. Potenza, Italy – J. M. Sarriegi, Spain
15:30 XP-RESILIENCE. *O. S. Bursi, Italy*
15:45 Assessment of civil infrastructure system seismic resilience using a compositional supply/demand frame work.
M. Didier – M. Broccardo – S. Esposito – B. Stojadinovic, Switzerland – S. Ghosh, India

16:00 Break

NORTH AMERICA: NIST FRAMEWORK

16:15 Introducing the NIST center of excellence for risk-based community resilience planning. Part I: Center of excellence overview, objectives and the community resilience modeling environment.
J. W. Van de Lindt – B. R. Ellingwood – T. E. McAllister – P. Gardoni – J. Sung Lee, USA

16:30 Introducing the NIST center of excellence for risk-based community resilience planning. Part II: Center of excellence community resilience testbeds, climate change and upcoming center research activities. *B. R. Ellingwood – J. W. Van de Lindt – D. Cox – N. Wang – H. Cutler – W. Peacock – P. Gardoni, USA*

16:45 Funtionality fragility assessment in the context of community resilience. *M. Koliou – J. W. Van de Lindt, USA*

17:00 Earthquake and tsunami fragility surfaces for a masonry infilled reinforced concrete building structure. A. R. Barbosa – M. Alam – D. Cox – *J. W. Van de Lindt, USA*

20:30 Social dinner
Restaurant "Il Circolo dei Lettori"
Via Gianbattista Bogino, 9

Wednesday, September 21
Castello del Valentino – Hall of Honour

NORTH AMERICA: OTHER FRAMEWORKS

8:30 Risk management considering resilience and enviromental impact. *Y. Dong – D. M. Frangopol, USA*

9:00 Acceptable and tolerable levels of risk: the role of immediate impact, resilience and human rights. *A. Tabandeh – P. Gardoni – C. Murphy, USA*

9:30 A community model for residential sector recovery. *E. J. Sutley, USA*

9:45 A sequential decision model for the design of resilient and sustainable buildings. *G. Warn, USA*

ASIAN FRAMEWORKS

10:00 General review on damage controllability and resilience of structures with FRP composites. *Z. Wu – M. F. M. Fahmy, China*

10:15 Analysis of the life recovery process of local people in Iwaki City after the great east Japan earthquake disaster using structural equation modelling. *M. Dan – M. Kohiyama, Japan*

10:30 Resilience of concrete frames with damage-free mechanism. *X. Lu – Y. Cui – J. Liu, China*

10:45 Structural resilience measurement of buildings subjected to earthquakes. *Q. Jiang – X. Lu, China*

11:00 Break

ECONOMIC RESILIENCE

11:15 Business resilience against earthquake disasters: observations from past Japanese earthquake disasters. *Y. Kajitani – H.Tatano, Japan*

11:30 Resilience-based geotechnical design. *M. Uzielli – M. Zei, Italy*

EMERGING TECHNOLOGIES

11:45 Chile resiliency: a review of the housing and health sector. *R. L. Boroschek – R. Retamales, Chile*

12:15 Emerging technologies: enablers of resilience in natural disasters. *G. Bacigalupe – A. Rosenberg – S. Astorga – M. Bussio – S. Ramis, Chile*

12:30 Measurement-based structural identification for robust post-earthquake vulnerability predictions. *Y. Reuland – P. Lestuzzi – I. F. C. Smith, Switzerland*

12:45 Novel connection for accelerated bridge construction with dissipation and recentering capabilities. *S. A. Mitoulis – J. R. Rodriguez, UK*

13:00 Use of seismic isolation for improving the seismic resilience of existing steel structures. *D. Lignos, Switzerland*

13:15 Break

INFRASTRUCTURE RESILIENCE

14:15 Field reconnaissance of August 24 Central Italy earthquake. *G. P. Cimellaro, Italy*

14:45 Re-conceptualizing resilience in disasters from transdisciplinary perspectives. *D. Atallah – G. Bacigalupe – P. Repetto – A. Vàsquez, Chile*

15:00 Resilience of isolated bridges with soil structure interaction. *D. Forcellini, San Marino – M. Tanganelli – S. Viti, Italy*

15:15 A new network model for probabilistic assessment of the resilience of the fuel distribution system of coastal British Columbia. *R. Costa – T. Haukaas – S. Chang, Canada*

15:30 Time-series analysis for the calibration of causative models of spatially distributed infrastructure interdependencies in post-disaster recovery.
F. Rigato – M. A. Zanini, Italy – P. Bocchini, USA

15:45 Derivation of bridge functionality loss curves for the resilience analysis of a road network exposed to seismic risk.
P. Gehl, France – D. Ayala, UK

16:00 Immediate resilience: numerical simulation and implentation issues.
M. Domaneschi – L. Martinelli, Italy

16:15 Closing Remarks

Thursday, September 22

7:45 Transfer by bus to Ispra - JRC Center.

10:30 Welcome at the JRC Visitor Center.
Visit of the European Laboratory for Structural Assessment.
Visit of the European Crisis Management Laboratory.

13:15 Lunch

14:15 Welcome address by Mr. Dan Chirondojan, Director of Space, Security & Migration.

14:35 Advances in risk and resilience assessment for the built environment. *G. Tsionis, JRC*

14:55 Resilience of networked interdependent infrastructures. *G. Giannopoulos, JRC*

15:15 Break

15:45 Panel discussion

18:00 Closing remarks

19:00 Welcome dinner

21:00 Return to Torino

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As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.

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